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An Essay on the Design of Mobile Offshore Drilling Units

Prepared for the
Royal Commission on the Ocean Ranger
Marine Disaster

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I. Introduction

A. Purpose

This essay is intended to provide an overview of the design procedure for a mobile offshore drilling unit from conceptual studies through rig operation. An overview of this procedure is shown in Figure 1. The information presented is based on the experience of SEDCO/Earl and Wright and does not necessarily reflect an industry standard.

B. Time Constraints/Overlapping Phases

The following description of the design process implies a well defined boundary between each phase and between the steps within each phase. In practice, time constraints may dictate an overlap between steps and phases. For example, construction of the basic structure may begin before all of the machinery and outfitting details are complete.

C. The role of the various participants are identified as they are likely to occur during the design process. Section 5 of this essay summarizes these roles and identifies potential gaps in responsibility and consequence thereof.

II. Design Phase

The following comments regarding the design phase process are intended to be general in nature and hit the highlights only.

The approach, circumstances and available time frame can vary greatly from job to job. Nevertheless the entire process must be completed. There are, finally, no short-cuts.

A. Iterative Nature of Design

The design of a Mobile Offshore Drilling Unit (MODU) is largely an iterative process to provide as the final product a drilling tool which has been, to the extent possible, optimized for the task it must perform.

To arrive at this final result a great deal of effort by many participants has been expended. Many variations and possibilities of configuration and structure have been explored. Through an iterative approach, the best design for the particular task is developed. The design continues to evolve as the process proceeds.

The following sections of this Design Phase aspect will outline this procedure as applied by SEDCO/Earl and Wright in the design of a semi-submersible drilling unit. While the same general approach applies to drillships and jackups, the semisubmersible will be used for illustrative purposes.

B. Conceptual Design

1. Prospective Client

Normally the first thing to develop must be the requirement or need for the design and construction of a new semi-submersible unit. Due to the costs involved, a client for leasing of the unit should ideally be available before the design process begins. Of course speculation or anticipation are other reasons for initiation of the

design process. There is merit in having a design, be it concept only, ready to aid in the development of a potential project. A concept design can cover a fair range of capabilities and is a good starting point from which to develop the exact needs of a client. Elements of the Conceptual Phase are shown in Figure 2.

If a client is involved he would be included in the conceptual design phase and his questions and comments would be considered and answered.

2. Basic Operational Parameters

To define the size and capability of the unit, basic operational parameters must be defined. These parameters include the following:

a. Area of Operation
b. Basic Environment
   - Wave height and period
   - Winds
   - Current
   - Any ice or icing requirements?
   - Service Temperatures
c. Motions limitations
d. Required pay load (deck and hull)
e. Type and capability of the mooring system
f. Self-propelled or not/transit requirements
g. Basic crew size
h. Regulations

These, of course, are only a few of the operational parameters that need to be addressed. However, these are the important items that if correctly defined and analyzed will result in the proper type and size of unit.

A semi-submersible unit of course is not always the outcome or proper choice as to type of unit. Yet with the rough or deep water

environments of today's drilling locations a semi is many times the natural, logical choice. This is based on the excellent motion characteristics of a semi in all sea states which improves drilling efficiency by minimizing downtime due to excessive heave or pitch/roll motions. The bottom line is being able to drill for as great a percentage of the time as practical.

3. Initial Sizing/Configuration

Studies proceed on the basis of the above parameters and should result in the sizing of a unit within 10 percent or so of the final design sizing.

Among the components to be determined for a semi-submersible are the following:

a. Number and size of columns.
b. Overall size of unit for stability and for layout of basic functions.
c. Pontoon volume which translates to cross section and length.
d. Height of unit, keel to deck.

4. Stability/Initial Motion Studies

Stability is of primary concern in the initial sizing of components.

To check the stability, a gross expected lightship is developed from past experience of weights of drilling and ship service equipment as well as weights of structural components.

A required water plane area and moment of inertia based upon a GM requirement for the intact stability case is determined and the column number, size and spacing consistent with function layout is developed. At this stage damage stability is not usually addressed as the columns and hulls can be subdivided into acceptable volumes to survive damage.

Hull volumes will be sized based primarily on hull liquid requirements (i.e. fuel oil and drill water) and on transit draft requirements.

Using the results of the initial sizing and stability an analytical motions study for the unit at operating draft will be made. Results will be compared with the motions of other vessels. Besides the heave motion amplitude the natural period is also determined.

5. Results

A concise report summarizing the findings of the concept study is produced. These results are reviewed against the required parameters and discussed with the prospective client.

In addition, if the proposed unit's configuration departs sharply from the norm, an "approval in concept" with a Classification Society should be considered. This may forstall future problems.

Also at this time a cost estimate for the concept unit should be made to help develop the operating day rate.

With a favorable decision from a client and from the drilling company management the stage is set for the next step in the design process.

C. Design Basis

1. General

The next subject is the preparation of a complete design basis.

The operational parameters or criteria of the concept phase are of course carried forward to become part of the design basis. In addition many other aspects are tied down with the aim that the final

product will truly meet the needs of the client and the drilling company.

The following sections indicate some of the information to be defined.

2. Detailed Operational Requirements

All aspects of operational requirements must be defined to the satisfaction of the client and the drilling company. This includes basic criteria for ship's service and drilling systems as well as structural aspects such as the required fatigue life.

3. Classification/Registration Decision

A decision regarding the classification society to be used and the country of registry must be made at this time in order to allow proper design to meet the appropriate requirements.

4. Additional Regulatory Requirements

A decision as to the regulatory agencies to be involved is also required. C.C.G., USCG, COGLA, DEn are examples of these agencies. Additional requirements imposed by the IMO Rules may also be required dependent upon the Country of Registry. It is important that all the regulatory bodies involved be defined such that a proper and economical approach to the rules can be made. This would include country of registry and operations area regulatory bodies governing the particular operations area.

5. Design Basis Approval

The above listed operational and environmental criteria and well as the Classification/Regulatory agencies to be met should be approved by the client and the drilling company.

In addition, the technical approach for the different disiplines (structural, mechanical and electrical) should be formalized in an in-house design procedure.

D. Preliminary Design

1. General

With a defined and accepted design basis and a basic concept unit developed, the preliminary design is performed. The Design Phase is shown in Figure 3.

2. Arrangements

Basic arrangements of the deck are developed to confirm or modify where necessary the space allocations determined for the concept unit.

3. Structural

a. Framing scheme: a basic framing scheme is developed for the unit based on loading requirements (both deck loadings as well as environmental loads). Simple computer modeling and analysis and also past experience is utilized in the development of the framing scheme and the basic member sizes. The computer modeling is particularly useful in doing trade-off studies in developing the bracing scheme layout. It is also used to develop basic axial, shear and bending moments in members of the main space frame. Emphasis is placed on developing a simple straight forward framing system with inherent redundancy in case of damage. Several structural drawings indicating the basic structural scheme and sizing are produced.

b. Weight Estimates - An estimate of the structural steel weight is made.

4. Naval Architecture

With a knowledge of the regulations to be met and the required capabilities such as deck load and hull storage capacities, the preliminary naval architectural design is done.

a. Lightship Weight/VCG Estimates

A lightship weight and vertical center of gravity (VCG) estimate is of primary concern and is a necessary piece of information to develop early in the design. The estimate developed in the conceptual stage is therefore defined further.

An estimate of lightship is necessary to determine the required waterplane areas of the stability columns.

b. Stability/Compartmentation

Using a computer program the unit is defined using the conceptual design configuration and sizing as a starting point. The hydrostatics and intact stability is determined, with iteration on sizes as necessary to meet stability and loading requirements. Compartmentation is defined and damage stability cases analyzed.

c. Motions

The motions of the unit are determined by computer. Many iterations of column size and hull configuration are made to optimize the motions as much as practical.

d. Downtime Analysis

A drilling efficiency or downtime analysis can now be performed. All the basic data such as the wave height exceedence curve, rig motions and definition of the drilling

tasks and durations allow use of our computer program AESOP to arrive at a result.

This downtime analysis is not always done but is dependent on the particular conditions.

5. Mechanical/Electrical

The following basic mechanical and electrical work is done at this stage.

a. System Requirements/Schematics

The requirements for the basic bilge, ballast and cooling water system are determined and schematic drawings of the systems made.

b. Equipment Arrangements

Basic layouts are done for the mechanical equipment including the pump rooms in order to verify space requirements and allocation.

c. Initial Power/Electrical Load Analysis

An initial power and electrical load analysis is performed to determine the required generator capacity and to produce a simple one-line power distribution drawing.

d. Equipment Weights

An estimate of the equipment weight is made for inclusion into the lightship estimate.

6. Client Approval

The results of the preliminary design phase are discussed with the client and comments received for incorporation where necessary in the final design phase.

7. Classification/Regulatory Approval in Principle

At this point a decision can be made as to the need or value in submitting the preliminary design package to the regulatory agencies for "approval in principle". A submittal of this nature can settle basic questions, clear the way for the final design and "get the vessel in-line" and introduced to the agencies.

E. Model Testing

For a new configuration or for a vessel that differs significantly from other designs it is necessary to conduct model tests to verify loads and motions developed by analytical means. Following are the type of model basin and wind tunnel tests to be considered.

1. Motion Response

Determine the heave, pitch, roll, surge and sway response of the unit in both regular and random seas while at the operating draft. Also determine the natural period of the various motions.

2. Wave Passing

For the maximum 100 year design wave determine the required survival draft necessary to pass the wave without having wave slam on the deck structure. Also measure the acceleration at the deck level due to the units motions.

3. Towing/Proplusion Requirements

Determine the resistance forces while towing the unit at shallow and deep draft for transit conditions at various speeds. This will

translate into a power-speed curve and size the propulsion system.

4. Wind/Current Forces

Development of the wind forces on the superstructure and the current forces on the below water members has unitl recently been done empirically using the requirements presented in classification/regulatory codes such as the ABS MODU Rules.

Recently however some regulatory bodies require that proper model tests be carried out to develop the forces and overturning moments.

F. Final Design

With the project still on-line the final design is now to be done. The final package will be a set of documents (drawings and construction specifications) for classification/regulatory approval and will define the unit as it is to be built. Shipyard bids will be obtained using these documents.

1. Detailed Arrangements

Detailed arranagement drawings will be developed for all spaces including the quarters and the drill floor. Particular attention is paid to the quarters layout to meet the regulations and to the drill floor to provide optimum drilling efficiency.

2. Structural

Several different aspects require design and documentation for submittal to the classification/regulatory bodies.

a. Overall Structural Analysis

The overall analysis of the main space frame is done using a

structural computer program. The program accounts for the motion and stiffness of the structure.

Many different types of loading conditions are studied. They include:

1) Static vertical loads

   Vessel lightship, deck and hull loads balanced by buoyancy forces.

2) Static damage conditions

   Vertical loads plus horizontal loads due to heel.

3) Dynamic loads due to motions

   A motion analysis computer program is used to develop hydrodynamic rigid body motions and associated loads. For various headings, several frequencies of waves are run through the unit. A linking computer program combines the dynamic loads with the vertical load effects.

It is of interest to note that some members are governed by the smaller height, shorter period waves rather than by the 100 year wave. This is due to the geometry or spacing of the unit's elements where pry forces, for instance, can thus be maximized. Nevertheless all reasonable wave height and period relationships up to the maximum specified design wave are investigated.

b. Local Member Design

The multitude of local scantlings are designed to meet the required loads imposed by the function of the area and in some cases the hydrodynamic loads. Requirements of the classification society rules are met as well as additional self-imposed codes.

c. Strength Book

The overall space frame and local member design work is developed together into a "Strength Book" for submittal to and approval of the classification society and regulatory bodies where necessary.

d. Fatigue Analysis

A fatigue analysis is an important part of the overall design due to the complex nature of the semi-submersible structure and the inevitable restraints and stress risers built into the structure.

raiser

The items involved in a fatigue analysis include:

1. The annual distribution of wave heights.
2. Stress RAO's of sensitive fatigue locations.
3. Allowable stress ranges versus cycles to failure information (S-N curves).
4. Cumulative damage effect.

Some of the classification societies and many of the regulatory agencies have their own fatigue requirement which are to be met. ABS is presently developing their own fatigue rules and are versed in applying and checking fatigue for various regulatory agencies.

e. Redundancy Analysis

Redundancy analyses have recently been required by selected regulatory agencies as a result of a major accident. The analysis involves the loss of a member or node for any unspecified reason. This effect is combined with a certain environment. This is a reasonable requirement but is only

fairly easily met by a redundant type space frame structure.

3. Naval Architecture

The naval architectural work is now finalized using the preliminary design work as the basis.

a. Intact and Damage Stability Analysis

A "Hydrostatics and Stability Book" is produced for submittal and approval of the classification society and certain of the regulatory bodies. At this stage it is unlikely that the dimensions of the unit or the stability column sizes will change appreciability. The sizes should be fairly well tied down by the preliminary design and this is basically a review and documentation task.

b. Mooring Analysis

The capability of the mooring system is documented.

"API Recommended Practice for the Analysis of Spread Mooring Systems Floating Drilling Unit's (API RP2P) is used for the criteria of design. This is augmented by any regulatory body requirements. In many instances this study is done only for the Owner and is not submitted for approval.

c. Lightship/Vertical Center of Gravity Data

The final lightship and VCG estimate is prepared and used in the stability review.

4. Mechanical/Electrical

The final mechanical/electrical work for the design set is now done.

a. Schematics/Flow Diagrams

Final system requirements are identified and incorporated in the schematics and/or flow diagrams. An electrical load analysis and power distribution drawings are prepared.

b. Pipe Sizing/Routing

Based on acceptable pressure loss, flow velocities and classification/regulatory requirements, pipe sizes are determined. Detailed routing may be specified for critical systems if the builder lacks experience in this area.

c. Component Selection

Pumps, valves, pressure vessels, heat exchangers and other major components are specified together with major power generation and electrical distribution equipment.

5. Construction Specification

A Construction Specification is prepared as part of the bid package.

The function of the Construction Specification is to define the material, equipment and workmanship required for the completed unit. A partial list of the items included in the specification are the following:

a. Structure

Includes workmanship and steel material requirements.

b. Welding

Materials, procedures and inspection requirements.

c. Mechanical/Electrical

Basis for design of systems, materials and workmanship.

d. Outfitting/Lifesaving

Defines a mulititude of items required for a completed vessel. Lifesaving appliances are an important part of this section.

e. Weight Control

Can be a problem and requires control during the construction phase.

f. Tests and Trials

A listing of the dock and sea trials required to prove the seaworthyness of the unit and also verifies proper operation of the various systems.

6. Classification/Regulatory Approvals

Most items involved in the design of the semi must receive approvals for classification. In addition approriate regulatory approvals due to the flagging and area of operation must be received.

Many different groups within the society or agency must combine to fully review a unit. As a result the approval process can be quite lengthly. Very seldom is the design fully approved before the project is put out for construction bids. Therefore during the construction period the approval process goes on for not only the construction documents but also for the design aspects.

To minimize possible changes at the shipyard, particulary after steel order, an effort is made during design to submit the job in segments to the agencies. For instance the components to be fabricated first

(such as the lower hulls) are submitted first for approval.

7. Bid Package

The bid package is comprised of the design drawings and the Construction Specifications. To these are added the bidding instructions.

The designer will normally prepare an estimate of the construction costs at this time to provide a basis for reviewing the bids.

III. Construction Phase

A. General

The fabrication process begins after the design process is complete. The fabrication process must be done in a professional, orderly manner by all parties involved in order that a safe product can be developed. If the construction process is not done properly the best of designs will be a failure.

The first thing that must occur is that the owner/designer chose a competent builder with adequate facilities and personnel. As shown in Figure 4 the designer and owner should meet with potential bidders and their subcontractors to determine their qualifications. It is very important, that subcontractors be included in this process because in our experience subcontractors have in a few cases been totally unqualified for the job even though the general builder was qualified. The general builder normally choses these subcontractors strictly based on their low bid price.

After the list of qualified bidders is developed, the complete design package as approved by the regulatory bodies should be issued to the builders for bidding. This package should be as complete as possible including owner-furnished equipment (OFE) drawings such that changes are not required at a later date. Many times, due to the time frame involved, this is not possible.

The bid price developed by the builders should not vary by more than 20 percent of the designer's estimate. If the builder is high or low it may be that he does not understand the scope of work. If the bid price is very low this might indicate that the builder intends to use inferior products.

It was stated above that the design package should be complete. This is the best way to start fabrication. However, we have used the so called "fast-track" method in the past where construction is begun prior to

completion of the design. The primary advantage to this is that the project is completed before market conditions change the need for the project and also to save some costs. There are two things which must occur if this method is to be used:

1) Regulatory bodies must work in a very timely fashion to review design items. If they don't, expensive changes may be required in the later phases of construction.

2) The designer and builder must assure that the as-built structure is not sensitive to construction changes. For instance, if a space frame tubular must be cut to install a newly defined piping system, dead load stress will be redistributed to the uncut section. This must be accounted for.

B. Schedule and Erection Sequence

After the builder is chosen by the designer and owner and the owner has made the decision to proceed, the contract is negotiated with the builder. The contract will state a delivery date which the builder must meet with his construction schedule and his proposed fabrication and erection method. It is very important that the designer review these. The contruction schedule will indicate if items such as OFE can be provided at the time indicated. If it can not then the schedule and/or fabrication method might have to be revised. The fabrication/errection method are very important. Many methods cause some locked in stress in the unit which must be allowed for in the design calculations. This is true for mechanical systems as well as structural systems.

If the above procedures are acceptable, material can be ordered. One of the major problems of fabrication in the past has been that material must be ordered significantly before the design is complete. If steel procurement lead times could be shortened, better designed and ligher vessels would result.

C. Owner's Shipyard Team

Prior to the fabricator beginning work on the job, the designer installs his field team at the various construction sites. The people in charge of the field team at the builder's yard should be experienced professionals who are very familiar with the design and the entire design/fabrication and negotiation process. Depending upon the owner and circumstances, this team will vary in size and composition from a small administrative staff to a larger group including structural, mechanical, and electrical engineers and naval architects. Personnel who will operate the vessel should be incorporated into this team, along with trainees where possible. An owner's inspection team may also make up part of this group. The project team should meet with ship yard personnel, the regulatory bodies and the owner at regular intervals to assure that everybody is working toward the same goal. Namely, the construction of a quality product, on time and within budget.

D. Preparation of Shipyard Drawings/Approval

Part of the construction team's job will be to review shop drawings The Builder will produce shop drawings with bills of material, material substitutions and design changes to suit the required fabrication. These shop drawings must adhere to the design philosophy. For instance, if a structural joint is fatigue sensitive, the fabricator must not route his piping through this area. The designer's team and regulatory bodies will assure this is done by checking the shop drawings. Ideally, the shop drawings should be complete prior to commencement of fabrication. In this regard, the designer should provide the fabricator with OFE drawings which have been approved by the regulatory bodies prior to development of the fabrication drawings. In this way, changes and revisions can be prevented due to use of assumed equipment data. As with the erection/fabrication procedure, all items and details installed on the project must be shown on the shop drawings such that a full review of the construction is accomplished. If design decisions are left to individual personnel in the yard, the only people who might know about a detail are the persons who installed it (i.e. a welder) and an inspector. In may instances these people are not qualified to judge on the adaquacy of the detail.

E. Changes

If a change is made to the design by the owner, designer or builder, the impact on the overall design should be assessed prior to modifying the shop drawings. For instance, the excess weight that would be added to a floating vessel might affect the stability to an extent that the project is no longer viable. This weight report should be produced by the builder at set intervals to assure the project is not adversely affected. Historically, the biggest problem that has occured on semi-submersible structures is weight growth and it's effect on the design concept.

F. Fabrication and Erection

Fabrication can begin after the shop drawings have been completed. In practice, shop drawing production and approval often extends well into the actual fabrication period. The designer, regulatory bodies and builder's inspection teams should work hand in hand to assure that a quality product is produced. This includes assuring that the proper materials are used, that they are installed correctly by qualified personnel and that proper documentation is maintained. The builder should endevor to install equipment prior to erection of subassemblies such that access holes for equipment will not be required. The equipment and other outfitting items must be in good working order when installed. If at any time the equipment, structure or other systems require repair during the fabrication sequence the builder must develop a repair procedure prior to doing the repair. All parties involved must agree to the procedure.

Inspection is an ongoing process during the fabrication of the vessel. This includes not only structural inspection of sub assemblies but inspection, testing and commissioning of equipment and systems after installation. Many builders prefer to delay inspections and testing until the later phases of the project. This is bad practice because the longer a repair (if required) is delayed the more difficult it is to do, and usually the more undesirable the final repair becomes.

G. Trials/Inclining

When the project is ready for delivery to the owner, sea trails and an inclining experiment are performed. If the inspections and testing and good weight report as described above have been done properly, this should not reveal any surprises. However, sea trials and inclining must also be treated very seriously since this is the final procedure where flaws in the fabrication or design can be detected prior to delivery. In this respect a very detailed procedure including documentation methods should be developed by the designer and approved by the regulatory bodies.

H. Documentation

An operations manual and construction portfolio are developed by the designer with the assistance of the operations personnel for use on the vessel. These must also be approved by the regulatory bodies. The operations manual should impart the design philosopy to the principal operating personnel. It should include detailed descriptions of how the safety systems work and where they are located. Since operating personnel must become very familiar with the manual it must be written such that it can be understood by the people using it. Similarly, a Construction Portfolio is produced to assist operating personnel with annual inspections. This Portfolio must be a document that provides for the most frequent inspection at the locations that experience and analysis has shown are the most critical locations. These inspections are recorded for future reference.

I. Acceptance/Delivery

The final acceptance and delivery of the vessel to the owner and certification by the regulatory bodies should not be a problem if the above inspections and documentation is carried out in a timely manner. This can only occur if all parties involved work together in an atmosphere of cooperation. In this respect, it should be understood that certain structures and systems require very professional work. For instance, a semi-submersible should not be considered the same as a ship during the

fabrication process. The semi-submersible due to its structural arrangement is geared toward pressure vessel quality rather than the lesser quality sometimes used on ships.

IV OPERATIONS

A. General

After official delivery of the vessel ot the Owner the drilling unit is the responsibility of the Operations Group which consists of the Rig Crew, Shore Based Staff, and Operations and Engineering Technical Support.

It is essential that the operations personnel be familiar with the operating limits of the drilling unit as well as the information which is contained in the Equipment Operations Manuals, and the Marine Operations Manual. This can be accomplished in several ways with a new build as well as an operating vessel.

1. Normally, several key members of the Operations staff which will operate the drilling unit will be part of the Owners shipyard team during the Builders Tests and Trails, certification, and acceptance of the unit. Participation of the operations staff during this critical phase of construction allows a smooth transition from construction to operations.

2. Key members of the crew will have been transferred from a similar drill rig.

3. All personnel who have received the training needed to obtain required documentation from regulatory or safety commissions.

4. The Operator will have land based as well as rig based classes and training programs to assure the drilling units are properly manned and operated.

   The following discussion of the Operation Phase of a drilling unit assumes that the rig crew operates the unit within the documented design limits of the vessel. The primary items discussed will concern classification, certification, repair, or modification of an inservice drilling unit.

B. Classification

A Classification Society, such as ABS, Lloyds, and DNV, serve as an independent agent in checking the design and construction of Mobile Offshore Drilling Units.

The design and construction guidelines established by these agencies also contain requirements which must be met to retain a drilling unit in class.

All essential vessel service systems, equipment, tanks, and structural elements are periodically inspected by the classification society to ensure they meet the societies minimum standards for safe operations.

If deficiencies are found the attendent surveyor will determine when the deficiency must be resolved. Minor problems can be cleared at the convenience of the rig operator, major problems have to be cleared before the drilling unit can resume operations. Failure to comply with Classification Society directives result in the loss of vessel class which is normally a requirement for insurance.

It is the responsibility of the Operations staff to prepare for the periodic inspections, and maintain adequate maintenance and inspection records for review by the surveyor.

C. Certification

Most drilling units must operate under the flag of an internationally recognized country, and comply with the countries guidelines for operating a drilling vessel. In many instances, the Classification Society is authorized by the flag country to verify that a drilling rig meets all requirements to remain certified to operate under their flag.

Several countries require that a drilling vessel obtain a Certificate of Fitness prior to operating in their waters, in addition to Classification and Flag requirements. In many instances, the Classification Society is

authorized to verify that a drilling rig meets all requirements to obtain a Certificate of Fitness.

It is the responsibility of the Operations staff to maintain records and prepare documentation as required to obtain and maintain Certificates of Fitness.

D. Repair

An damage or malfunction to equipment or structure which effects rig safety, classification, or certification must be reported to the appropriate Classification Society and Regulatory Bodies. The general sequence is illustrated in Figure 5.

It's the responsibility of the Operations Group to:

1. Inform all parties of the incident in a timely manner.
2. Obtain all data required to evaluate the damaged conditions.
3. Develop acceptable repair and inspections procedures including approval to commence operations.
4. Arrange for material and labor required to carry out the timely repair of the damaged equipment/structure.
5. Obtain documented approval of the repair by required agencies.

E. Modification

Any modification to the drilling unit which effects the safety, classification, or certification of the unit must be reported to the appropriate agencies.

It is the responsibility of the Operations Group to:

1. Obtain all data necessary to perform the required calculations, prepare design drawings and construction specifications.

2. Issue the design documents for regulatory and classification

approval.

3. Develop installation and inspection procedures which conform to safety and operation procedures.

4. Arrange for material and labor required to carry out the modification.

5. Arrange for documented approval of modifications by the appropriate agencies.

V. Participants/Case Studies

A. Participants

The major participants in the design, construction and operation of an offshore drilling unit have direct impact on the unit at various times and in various capacities.

Recognizing that the same organization can have multiple functions, the primary participants are the Owner, Designer, Builder, Drilling Contractor, Operator, Classification Society, and Regulatory Body.

Due to the number of participants and the complexity of the overall process, it is easy to visualize breakdowns in communications and disagreements on interpretation of various technical or regulatory requirements.

These potential problems are further compounded by the various combinations of participants that occur. The following represents two examples which highlight the potential discontinuties that can occur.

B. Case Study No. 1

The first example in Figure 6 represents an extreme but realistic example which has numerous possibility of gaps or discontinuties in the design-construction-operation process. The basic assumption are as follows:

- The drilling rig is designed by an independent designer who has no further involvement with the construction, or operation of the unit.

- Rights to the design are bought by a Builder, who builds the rig on speculation.

- The eventual Owner buys the unit and obtains a certificate of fitness to operate in a jurisduction not covered during the design and construction of the unit.

- Subsequently, the Owner leases the rig to the Drilling Contractor under a bareboat charter.

The above service requires several independent parties to separately interpret technical data and drawings to properly build and operate the drilling rig.

C. Case Study No. 2

The second example in Figure 6 represents an example which has minimized the possibilities of discontinuties in the Design-Construction-Operation process.

In this case:

- The Owner, Designer and Drilling Contractor are all the same organization.

- The Owner has a shipyard team wich includes members of the Design Group.

- The unit has been designed for specific operators with operators input into the design of the unit.

- The vessel has been classed and certified during design and construction to operate in the designated drilling jurisdiction.

In the above service the same group is responsible for design, construction and operation of the drilling rig.

D. Consequences and Responsibilities

The consequences of the discontinuties which are introduced during the process of designing, building and operating a drilling rig are difficult to evaluate; however, it would seem advantageous to have continuity from

initiation of design through operation of the rig as represented by Case Study No. 2.

The responsibility for each step in the overall process is also clearly delineated in Case Study No. 2 as opposed to Case Study No. 1.

The role of the Classification Society and Regulatory Body in establishing guidelines and minimum standards of design construction and operation as well as their participation in the design review, building inspection, and ongoing surveillance during operation is clearly understood. However, their responsibility in case of a faulty design, defective construction, or negligent operations, whether implied or actual, has not been addressed to date.

MOBILE OFFSHORE DRILLING UNIT
Design, Construction, and Operations

I Design Phase

- Criteria
- Conceptual Design
- Design Basis
- Preliminary Design
- Final Design
- Regulatory Approvals
- Documents for Shipyard Bids

II Construction Phase

- Obtain Bids/Shipyard Contract
- Design Construction Team for Office/Field
- Approvals of Shipyard Drawings
- Inspection of Shipyard Fabrication
- Inclining/Sea Trials
- Delivery

III Operations Phase

- Modifications
- Certifications
- Repairs
- Documentation

Figure 1

MOBILE OFFSHORE DRILLING UNIT
Conceptual Phase

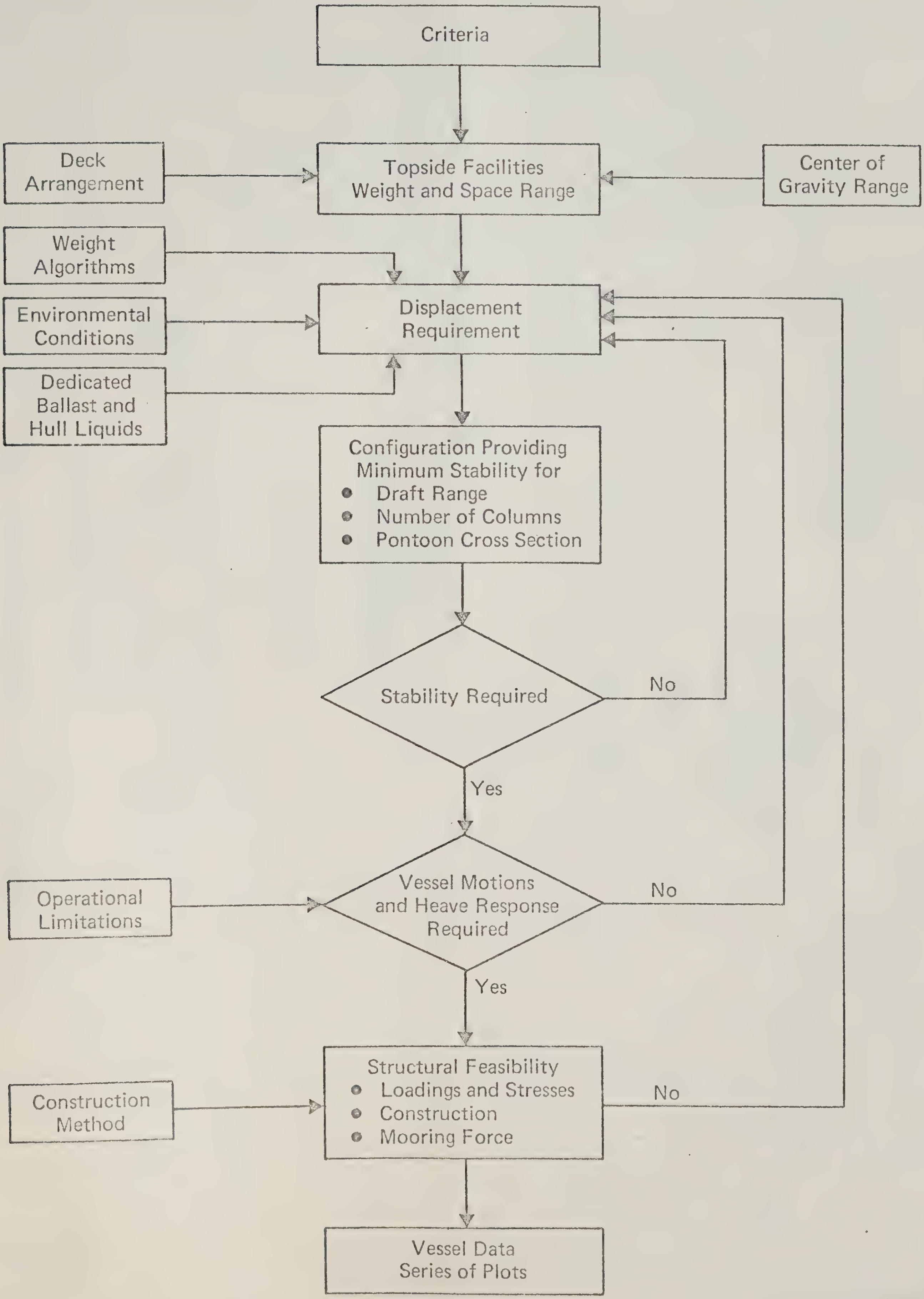


Figure 2

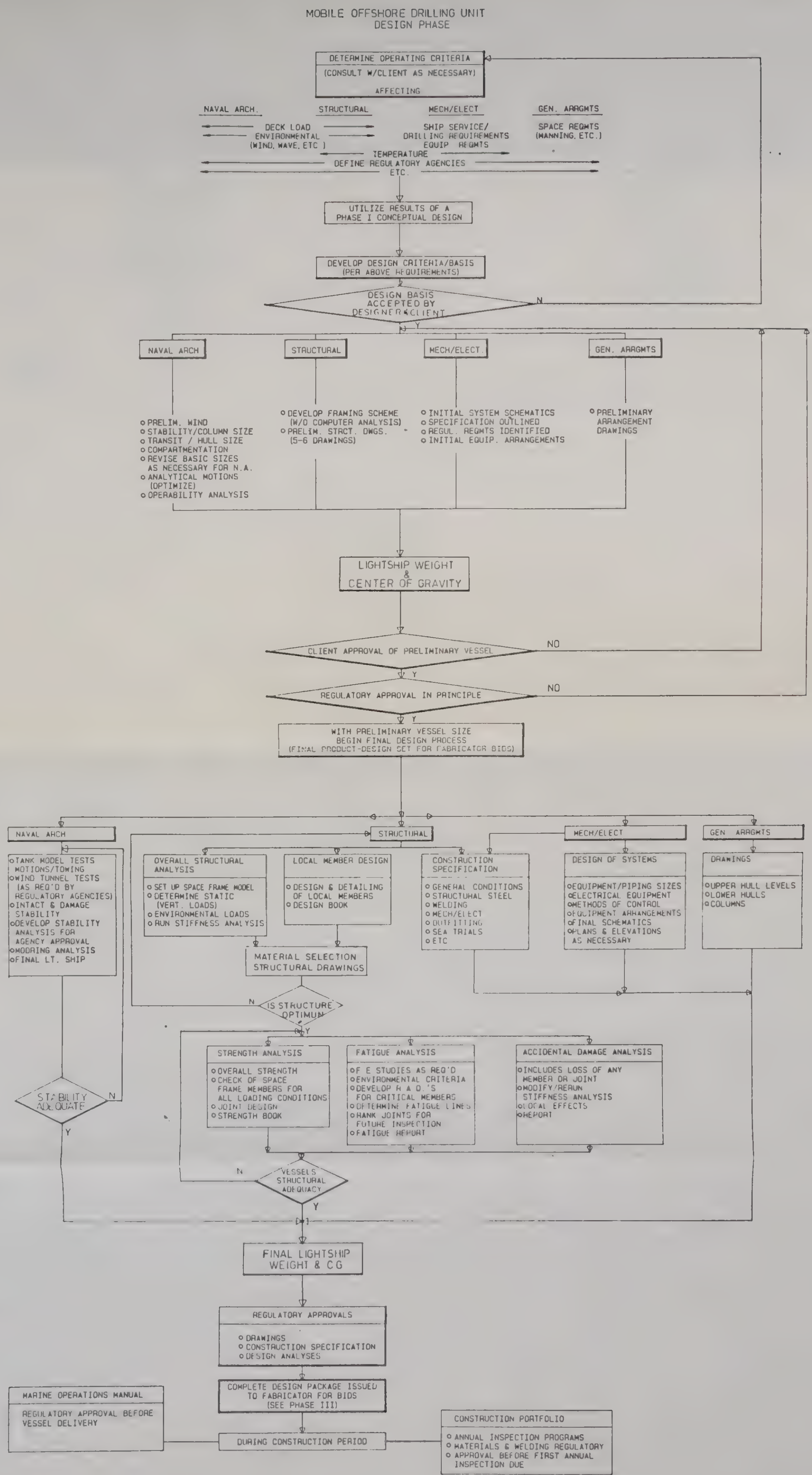

MOBILE OFFSHORE DRILLING UNIT
DESIGN PHASE
DETERMINE OPERATING CRITERIA
(CONSULT W/CLIENT AS NECESSARY)
AFFECTING
NAVAL ARCH.
STRUCTURAL
MECH/ELECT
GEN. ARRGMTS
DECK LOAD
ENVIRONMENTAL
(WIND, WAVE, ETC.)
SHIP SERVICE/
DRILLING REQUIREMENTS
EQUIP REQMTS
SPACE REQMTS
(MANNING, ETC.)
TEMPERATURE
DEFINE REGULATORY AGENCIES
ETC.
UTILIZE RESULTS OF A
PHASE I CONCEPTUAL DESIGN
DEVELOP DESIGN CRITERIA/BASIS
(PER ABOVE REQUIREMENTS)
DESIGN BASIS
ACCEPTED BY
DESIGNER&CLIENT
N
Y
NAVAL ARCH
STRUCTURAL
MECH/ELECT.
GEN. ARRGMTS
o PRELIM. WIND
o STABILITY/COLUMN SIZE
o TRANSIT / HULL SIZE
o COMPARTMENTATION
o REVISE BASIC SIZES
AS NECESSARY FOR N.A.
o ANALYTICAL MOTIONS
(OPTIMIZE)
o OPERABILITY ANALYSIS
o DEVELOP FRAMING SCHEME
(W/O COMPUTER ANALYSIS)
o PRELIM. STRCT. DWGS.
(5-6 DRAWINGS)
o INITIAL SYSTEM SCHEMATICS
o SPECIFICATION OUTLINED
o REGUL. REQMTS IDENTIFIED
o INITIAL EQUIP. ARRANGEMENTS
o PRELIMINARY
ARRANGEMENT
DRAWINGS
LIGHTSHIP WEIGHT
&
CENTER OF GRAVITY
CLIENT APPROVAL OF PRELIMINARY VESSEL
NO
Y
REGULATORY APPROVAL IN PRINCIPLE
NO
Y
WITH PRELIMINARY VESSEL SIZE
BEGIN FINAL DESIGN PROCESS
(FINAL PRODUCT-DESIGN SET FOR FABRICATOR BIDS)
NAVAL ARCH
STRUCTURAL
MECH/ELECT
GEN ARRGMTS
o TANK MODEL TESTS
MOTIONS/TOWING
o WIND TUNNEL TESTS
(AS REQ'D BY
REGULATORY AGENCIES)
o INTACT & DAMAGE
STABILITY
o DEVELOP STABILITY
ANALYSIS FOR
AGENCY APPROVAL
o MOORING ANALYSIS
o FINAL LT. SHIP
OVERALL STRUCTURAL
ANALYSIS
o SET UP SPACE FRAME MODEL
o DETERMINE STATIC
(VERT. LOADS)
o ENVIRONMENTAL LOADS
o RUN STIFFNESS ANALYSIS
LOCAL MEMBER DESIGN
o DESIGN & DETAILING
OF LOCAL MEMBERS
o DESIGN BOOK
CONSTRUCTION
SPECIFICATION
o GENERAL CONDITIONS
o STRUCTURAL STEEL
o WELDING
o MECH/ELECT
o OUTFITTING
o SEA TRIALS
o ETC
DESIGN OF SYSTEMS
o EQUIPMENT/PIPING SIZES
o ELECTRICAL EQUIPMENT
o METHODS OF CONTROL
o EQUIPMENT ARRANGEMENTS
o FINAL SCHEMATICS
o PLANS & ELEVATIONS
AS NECESSARY
DRAWINGS
o UPPER HULL LEVELS
o LOWER HULLS
o COLUMNS
MATERIAL SELECTION
STRUCTURAL DRAWINGS
N
IS STRUCTURE
OPTIMUM
Y
STRENGTH ANALYSIS
o OVERALL STRENGTH
o CHECK OF SPACE
FRAME MEMBERS FOR
ALL LOADING CONDITIONS
o JOINT DESIGN
o STRENGTH BOOK
FATIGUE ANALYSIS
o F E STUDIES AS REQ'D
o ENVIRONMENTAL CRITERIA
o DEVELOP R A O 'S
FOR CRITICAL MEMBERS
o DETERMINE FATIGUE LINES
o RANK JOINTS FOR
FUTURE INSPECTION
o FATIGUE REPORT
ACCIDENTAL DAMAGE ANALYSIS
o INCLUDES LOSS OF ANY
MEMBER OR JOINT
o MODIFY/RERUN
STIFFNESS ANALYSIS
o LOCAL EFFECTS
o REPORT
STABILITY
ADEQUATE
N
Y
N
VESSELS
STRUCTURAL
ADEQUACY
Y
FINAL LIGHTSHIP
WEIGHT & CG
REGULATORY APPROVALS
o DRAWINGS
o CONSTRUCTION SPECIFICATION
o DESIGN ANALYSES
COMPLETE DESIGN PACKAGE ISSUED
TO FABRICATOR FOR BIDS
(SEE PHASE III)
MARINE OPERATIONS MANUAL
REGULATORY APPROVAL BEFORE
VESSEL DELIVERY
DURING CONSTRUCTION PERIOD
CONSTRUCTION PORTFOLIO
o ANNUAL INSPECTION PROGRAMS
o MATERIALS & WELDING REGULATORY
o APPROVAL BEFORE FIRST ANNUAL
INSPECTION DUE

Figure 3

MOBILE OFFSHORE DRILLING UNIT
CONSTRUCTION PHASE

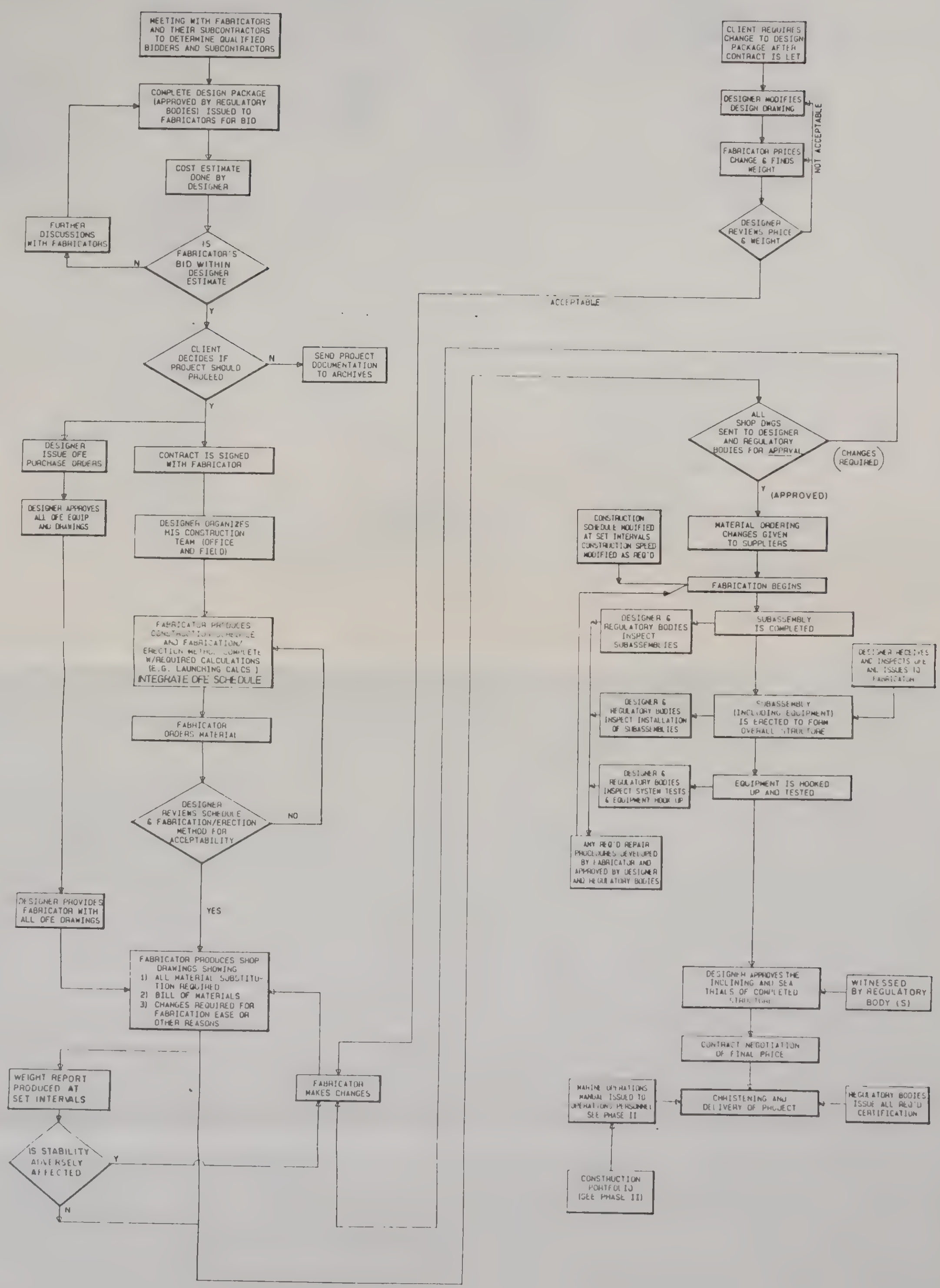
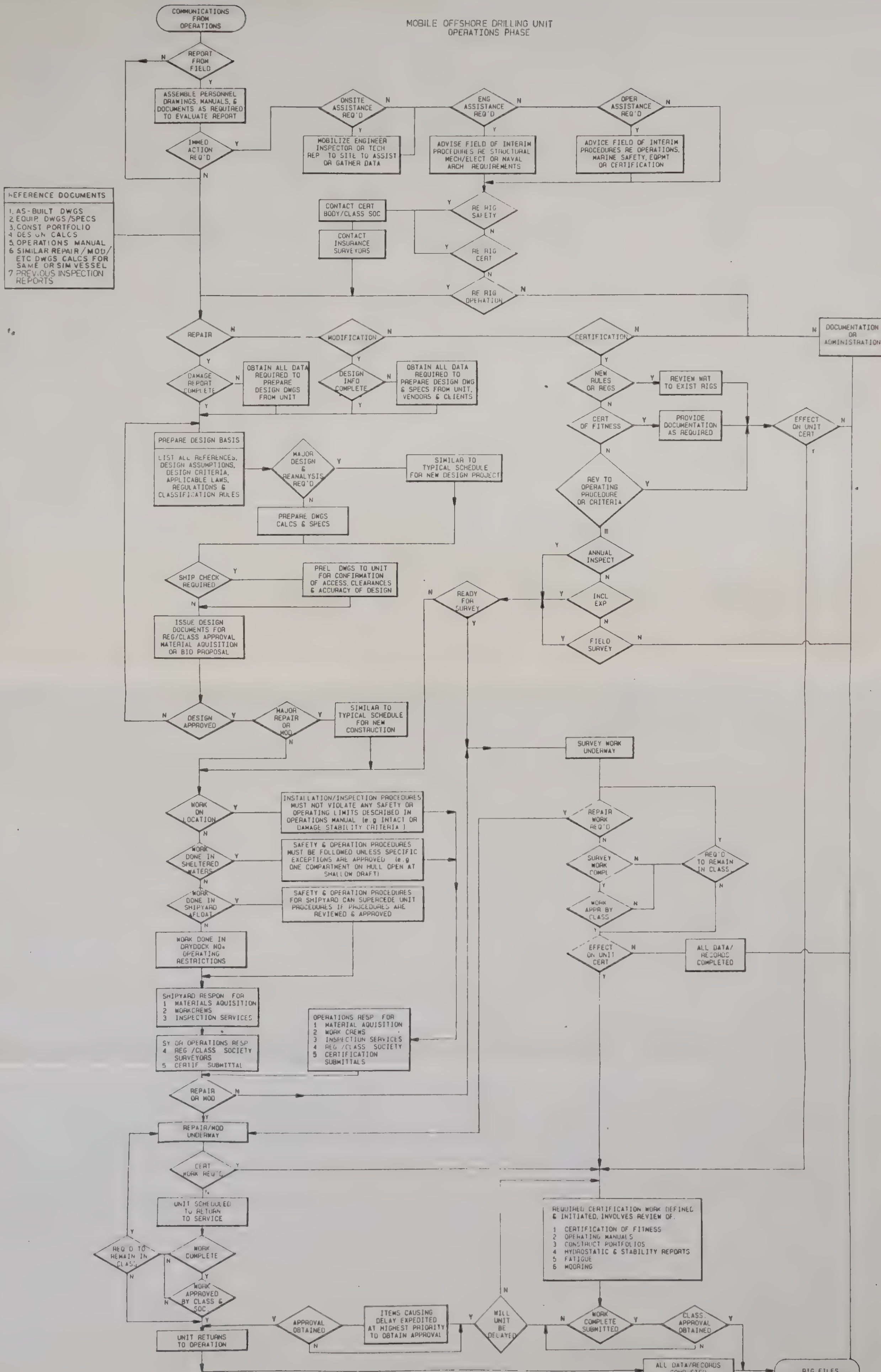


Figure 4



MOBILE OFFSHORE DRILLING UNIT
OPERATIONS PHASE
COMMUNICATIONS FROM OPERATIONS
REPORT FROM FIELD
ASSEMBLE PERSONNEL DRAWINGS, MANUALS, & DOCUMENTS AS REQUIRED TO EVALUATE REPORT
IMMED ACTION REQ'D
ONSITE ASSISTANCE REQ'D
MOBILIZE ENGINEER INSPECTOR OR TECH REP TO SITE TO ASSIST OR GATHER DATA
ENG ASSISTANCE REQ'D
ADVISE FIELD OF INTERIM PROCEDURES RE STRUCTURAL MECH/ELECT OR NAVAL ARCH REQUIREMENTS
OPER ASSISTANCE REQ'D
ADVICE FIELD OF INTERIM PROCEDURES RE OPERATIONS, MARINE SAFETY, EQPMT OR CERTIFICATION
REFERENCE DOCUMENTS
1. AS-BUILT DWGS
2. EQUIP. DWGS/SPECS
3. CONST PORTFOLIO
4. DESIGN CALCS
5. OPERATIONS MANUAL
6. SIMILAR REPAIR/MOD/ ETC DWGS CALCS FOR SAME OR SIM VESSEL
7. PREVIOUS INSPECTION REPORTS
CONTACT CERT BODY/CLASS SOC
CONTACT INSURANCE SURVEYORS
RE RIG SAFETY
RE RIG CERT
RE RIG OPERATION
REPAIR
MODIFICATION
CERTIFICATION
DOCUMENTATION OR ADMINISTRATION
DAMAGE REPORT COMPLETE
OBTAIN ALL DATA REQUIRED TO PREPARE DESIGN DWGS FROM UNIT
DESIGN INFO COMPLETE
OBTAIN ALL DATA REQUIRED TO PREPARE DESIGN DWG & SPECS FROM UNIT, VENDORS & CLIENTS
NEW RULES OR REGS
REVIEW WRT TO EXIST RIGS
CERT OF FITNESS
PROVIDE DOCUMENTATION AS REQUIRED
EFFECT ON UNIT CERT
PREPARE DESIGN BASIS
LIST ALL REFERENCES, DESIGN ASSUMPTIONS, DESIGN CRITERIA, APPLICABLE LAWS, REGULATIONS & CLASSIFICATION RULES
MAJOR DESIGN & REANALYSIS REQ'D
SIMILAR TO TYPICAL SCHEDULE FOR NEW DESIGN PROJECT
PREPARE DWGS CALCS & SPECS
REV TO OPERATING PROCEDURE OR CRITERIA
ANNUAL INSPECT
INCL EXP
FIELD SURVEY
SHIP CHECK REQUIRED
PREL DWGS TO UNIT FOR CONFIRMATION OF ACCESS, CLEARANCES & ACCURACY OF DESIGN
READY FOR SURVEY
ISSUE DESIGN DOCUMENTS FOR REG/CLASS APPROVAL MATERIAL AQUISITION OR BID PROPOSAL
DESIGN APPROVED
MAJOR REPAIR OR MOD
SIMILAR TO TYPICAL SCHEDULE FOR NEW CONSTRUCTION
SURVEY WORK UNDERWAY
WORK ON LOCATION
INSTALLATION/INSPECTION PROCEDURES MUST NOT VIOLATE ANY SAFETY OR OPERATING LIMITS DESCRIBED IN OPERATIONS MANUAL (e.g INTACT OR DAMAGE STABILITY CRITERIA)
WORK DONE IN SHELTERED WATERS
SAFETY & OPERATION PROCEDURES MUST BE FOLLOWED UNLESS SPECIFIC EXCEPTIONS ARE APPROVED (e.g ONE COMPARTMENT ON HULL OPEN AT SHALLOW DRAFT)
WORK DONE IN SHIPYARD AFLOAT
SAFETY & OPERATION PROCEDURES FOR SHIPYARD CAN SUPERCEDE UNIT PROCEDURES IF PROCEDURES ARE REVIEWED & APPROVED
REPAIR WORK REQ'D
SURVEY WORK COMPL
REQ'D TO REMAIN IN CLASS
WORK APPR BY CLASS
EFFECT ON UNIT CERT
ALL DATA/ RECORDS COMPLETED
WORK DONE IN DRYDOCK NO OPERATING RESTRICTIONS
SHIPYARD RESPON FOR
1 MATERIALS AQUISITION
2 WORKCREWS
3 INSPECTION SERVICES
SY OR OPERATIONS RESP
4 REG /CLASS SOCIETY SURVEYORS
5 CERTIF SUBMITTAL
OPERATIONS RESP FOR
1 MATERIAL AQUISITION
2 WORK CREWS
3 INSPECTION SERVICES
4 REG /CLASS SOCIETY
5 CERTIFICATION SUBMITTALS
REPAIR OR MOD
REPAIR/MOD UNDERWAY
CERT WORK REQ'D
UNIT SCHEDULED TO RETURN TO SERVICE
REQUIRED CERTIFICATION WORK DEFINED & INITIATED, INVOLVES REVIEW OF.
1 CERTIFICATION OF FITNESS
2 OPERATING MANUALS
3 CONSTRUCT PORTFOLIOS
4 HYDROSTATIC & STABILITY REPORTS
5 FATIGUE
6 MOORING
REQ'D TO REMAIN IN CLASS
WORK COMPLETE
WORK APPROVED BY CLASS & SOC
UNIT RETURNS TO OPERATION
APPROVAL OBTAINED
ITEMS CAUSING DELAY EXPEDITED AT HIGHEST PRIORITY TO OBTAIN APPROVAL
WILL UNIT BE DELAYED
WORK COMPLETE SUBMITTED
CLASS APPROVAL OBTAINED
ALL DATA/RECORDS COMPLETED
RIG FILES

Figure 5

Figure 6

Case Study No. 1

	Owner	Designer	Builder	Drilling Contractor	Operator	Class	Rig
Concept	X				X		
Design		X				X	X[3]
Build			X			X	X[3]
Drilling	X[1]			X	X		X[3]
Maintenance				X		X	
Repair				X		X	
Modification	X	X[2]				X	X[3]

1. Bareboat charter to Drilling Contractor.
2. May not be the original Designer.
3. May bemore than one Regulatory Body

Case Study No. 2

	Owner[1]	Designer	Builder	Drilling Contractor	Operater	Class	Rig
Concept	X				X		X
Design	X	X		X	X[2]	X	X
Build	X[2]	X[2]	X	X		X	X
Maintenance	X	X		X		X	
Repair	X	X		X		X	
Modification	X	X		X		X	X

1. Owner, Designer, and Drilling Contractor are the same organization.
2. Owner has shipyard team.
3. Unit designed for a specific Operators.